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THE INSULAR EXPERIMENT STATION
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THE DEPARTMENT OF AGRICULTURE AND LABOR
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CROSS-POLLINATION OF SUGAR CANE.

By H. B. COWGILL, Plant Breeder, Insular Experiment Station.

Sugar cane has been propagated from seed and the seedlings selected for the purpose of originating new varieties since 1887. This was begun in Java and in Barbados at about the same time, and it has since been taken up in nearly all the cane-producing countries of the world. Originally no record was made of the parentage of the seedlings, and in many cases not even the name of the seed parent was kept. Some very good varieties were originated by this method.

For commercial purposes cane is propagated asexually by cuttings. When it is propagated from seed the variation in the resulting generation, even from a single parent variety, is considerable. It is presumed that some, if not all, of the varieties are more or less heterozygous. It seems nevertheless desirable, in many cases, to make controlled crosses in order to combine such characters as vigor and disease resistance of certain varieties with the good qualities of other kinds.

METHOD OF CROSSING.

It would, of course, be desirable to eliminate all possibility of self-pollination. Attempts to emasculate the florets have been made, and a few seedlings have been produced in Barbados in that way, though, according to Bovell, the number of seedlings produced in any single season has been small. The work is very tedious, for the reason that the florets are small and the panicle is brittle. The latter is also produced at 10 to 15 feet from the ground, so that it is necessary to do the hybridizing on a scaffold and sometimes the wind makes the work very difficult.

Kobus (4),[1] in Java, planted a pollen-sterile variety on the lee-
Another method reported by Bovell (1) to be employed in Barbados is to plant two varieties which flower at the same time in alternate stools, called "checkerboard system," for the purpose of facilitating natural cross-pollination. It is, of course, impossible to form any conclusion as to the extent to which crossing takes place with the method, unless the type of seedlings produced by each variety when growing separately is known.

Two additional methods are described by Wilbrink and Ledeboer (6). By the first method the tassels of the variety to be used as the male parent are cut off and tied in position with the one to be used as seed parent. For protection against undesired pollen a screen is provided, having an opening on the leeward side for the entrance of the tassels. By the second method the pollen of the desired variety is collected and carried to the one to be used as the female parent. This latter method is also one which was suggested by D'Albuquerque (3). It is reported that the pollen adheres in masses, and also soon deteriorates, so that no very satisfactory results were obtained.

METHODS EMPLOYED AT THE INSULAR EXPERIMENT STATION.

Crossing has been practiced at the Insular Experiment Station of Porto Rico for four years. The method here described was found to be more suitable, for the reason that with its use a fairly large number of seedlings can be produced. The work has not yet progressed far enough to report results of the crossing, in respect to the quality of varieties produced. It has been possible, however, to study to some extent the populations of seedlings originating from different parentages, as to inheritance of characters in first-generation seedlings.

Bags made of cheese-cloth are held extended by heavy wire rings sewed into them. The bags when completed are 48 inches long and 18 inches in diameter. The rings are placed one at the top and the other 16 inches from the bottom, so that a skirt of 16 inches is left to be drawn in and tied around the stems of the panicles.

The bags are supported over the panicles by means of bamboo poles set in the ground. The poles have a crossbar at the top which is fastened to them by being wedged into notches cut into the second internode from the top, and the bags are tied to this crossbar. The poles are set on the windward side of the stools just before the

[1] Figures in parentheses refer to "Literature cited."

panicles "shoot;" when this occurs, a bag is immediately suspended over each panicle and tied around its stem, so that it is protected from all undesired pollen before any of the florets open.

The cane blossom is hermaphrodite, but it has been found that certain varieties are almost completely pollen-sterile, or at least self-sterile. This makes it possible to pollinate them with another variety, with the assurance that nearly all the seedlings will be offspring of two known varieties, a few usually also being produced as the result of the self-pollination of the mother parent.

The pollinating is done by placing panicles of the desired variety into a bag, in such a position that their pollen will be shed or carried by the wind to the florets, of the other variety as they open. One or two panicles are used at a time, and they are allowed to remain in the bag two or three days, being renewed as often as necessary while the florets are opening. It has been found of advantage to cut the panicles with stems 4 to 6 feet long, and to place their lower ends in a joint of bamboo filled with water, by which they can be kept fresh two or three days.

RESULTS ACCOMPLISHED.

Up to the present time, results can only be expressed in terms of the number of seedlings produced and the extent to which the characters of the varieties are combined. The method above described was first tried in 1915–1916. Ten crosses were attempted, of a single combination, and all but two produced seedlings, a majority of which, when mature, showed characteristics of both parents. In all, about 1,600 seedlings were produced, one panicle alone giving over 1,000 seedlings. (2)

In the following winter 1916–1917, thirty crosses, comprising nine different combinations, were attempted, and nineteen of them, comprising six combinations, were successful. From one combination 1,309 seedlings were obtained, and in all 2,589 seedlings were produced. The work was all done by one man and a helper, including the making of the bags.

In 1917–1918 it was impossible to secure the services of a competent man to perform the crossing until late in the season, and the seed of all varieties was also much less viable than in the preceding year. Thirty crosses were attempted, comprising nine combinations. Fifteen of these were successful and 1,794 seedlings were produced, 157 of which were from one combination and 735 from another.

Judging from the small proportion of the seedlings out of the large

number propagated by the old method that are of sufficient value to become widely cultivated, it appears that a large number of first-generation seedlings is essential. Considered from the point of view of Mendelian inheritance, if many factors are involved, which is probably the case, the chance of getting a desired combination of characters is very remote when only a few seedlings are grown.

EFFECT OF THE CROSSING.

In 1915–1916 the variety used as a pollinator was a dark-colored cane, while the seed parent was medium light. This made it possible to trace the color of the male parent in the offspring. Some other characters could also be traced in the seedlings in the same way. In the following year this cross was again made, and the same general effects were observed, many of the same types being again recognized. (2)

In the year 1916–1917, some of the parent varieties of groups of seedlings showed fewer differences than was the case with the varieties combined the year before, consequently it was less easy to see the effect of the crossing in the seedlings. In all cases but one, however, some of the groups showed distinguishing characters of both parent varieties.

The disadvantage in this method, in not being able to eliminate all possibility of self-pollination, ought not to be overlooked. On account of the chance of some selfing, it has been the practice to estimate the value of a cross from the entire group of seedlings produced, always making allowance for probable self-pollination.

SELF-STERILITY.

At least two of the old standard varieties are nearly pollen-sterile here. We have never succeeded in producing more than five seedlings from single flats of several hundred seeds planted, while if these varieties are pollinated by any of several seedling varieties good germination follows. Lewton-Brain (5) in Barbados examined the florets of about fifty varieties and found that some bore pollen nearly all of which was large, well-shaped and full of dark granules, while with some the pollen was smaller, more or less irregular in form, and without granular matter. A third class of varieties had an intermediate amount of normal, well-developed pollen.

Wilbrink and Ledeboer (6) describe a method of testing the pollen with iodine, to determine its viability. If the pollen grain con-

tains starch it was believed to be normal. We have not, however, found this test to be absolutely reliable.

CONCLUSIONS.

From the work reviewed in the foregoing paper the following conclusions are possible:

1. Sugar cane can be cross-pollinated and protected from outside pollen, and by this process a considerable number of seedlings can be produced.

2. Characters of the parent varieties are combined in the seedling by this process.[1]

LITERATURE CITED.

(1) Bovell, J. B.—Report of sugar-cane experiments. In Rpt. Barbadoes Dept. Agric., pp. 16–16. 1914.

(2) Cowgill, H. B.—Studies in inheritance in sugar cane. In Jour. Dept. Agr. Porto Rico, vol. 2, No. 1, pp. 33–41. 1918.

(3) D'Albuquerque, J. P.—Note on the artificial cross-fertilization in the sugar cane. In West Indian Bulletin, vol. 1, no. 2, pp. 182–184. 1900.

(4) Kobus, J. D.—De zaadplanten de Krusing van Cheribonriet met de Inglisch indische Varietiet Chunnee. In Mededeelingen vat het Proefstation voor de Java-Suikerindustrie, III, Nos. 1, 12, 21, 33.

(5) Lewton-Brain, L.—Hybridization of sugar cane. In West Indian Bulletin, vol. 4, no. 1, pp. 63–72. 1903.

(6) Wilbrink and Ledeboer, F.—De geslachaelijke voortplanting bij het Suikeriet. In Mededeelingen van het Proofstation voor de Java-Suikerindustrie, no. 6. 1911.

[1] It should be expected that the desirable combinations could be perpetuated in hybrid condition because of the asexual method of propagation, a rather unusual advantage among our field-crop plants.—(Editorial note by L. H. Smith.)

A PINEAPPLE FERTILIZER EXPERIMENT.

By P. González,[1] Horticulturist.

Full credit should be given our former plant breeder, Mr. H. B. Cowgill, for the fertilizer trial about to be reported on. The first crop was beginning to be harvested when Mr. Cowgill resigned. After his departure, the task of completing the harvest has devolved upon us and the making of a preliminary report based on the notes so obtained and on such data as were found available in the files of the Division of Agronomy and Horticulture.

The field selected for this experiment occupies an area of 0.67 acre and is situated on the slope of a hill facing northeast, and about 8 meters higher than the surrounding valley land. The approximate altitude of this level land being 80 feet above the level of the sea, the altitude of the field above that level can be taken to be about 106 feet. The angle of inclination of the slope is about 13.76 and the grade 22 per cent per meter.

SOIL.

Conditions of drainage, although not uniform, are fairly good. The soil is a stiff clay derived from the decomposition of the layer of shale upon which it rests. At the northwestern corner of the field the shale fragments can be seen at the surface mixed with the top soil. Analyses of this soil will be available for report of the 1919 crop. For the present an analysis[1] is given below of the soil and subsoil of a hill close to it, and of the same formation and physical characteristics.

	Sample No. 24. (*Soil*)	Sample No. 25. (*Subsoil*)
Insoluble residue	55.89	53.30
Volatile matter	14.48	11.60
Fe_2O_3	11.40	12.88
Al_2O_3	17.40	21.24
CaO	0.17	0.17
MgO	0.56	0.65
K_2O	0.22	0.22
P_2O_5	0.10	0.07
Total nitrogen	0.30	0.14
H_2O (air dry)	5.76	5.70

[1] Thanks are due the Director for his assistance in preparing the manuscript.

[1] These analyses were found on file in the records of the Division of Chemistry of the Insular Experiment Station, Río Piedras, P. R.

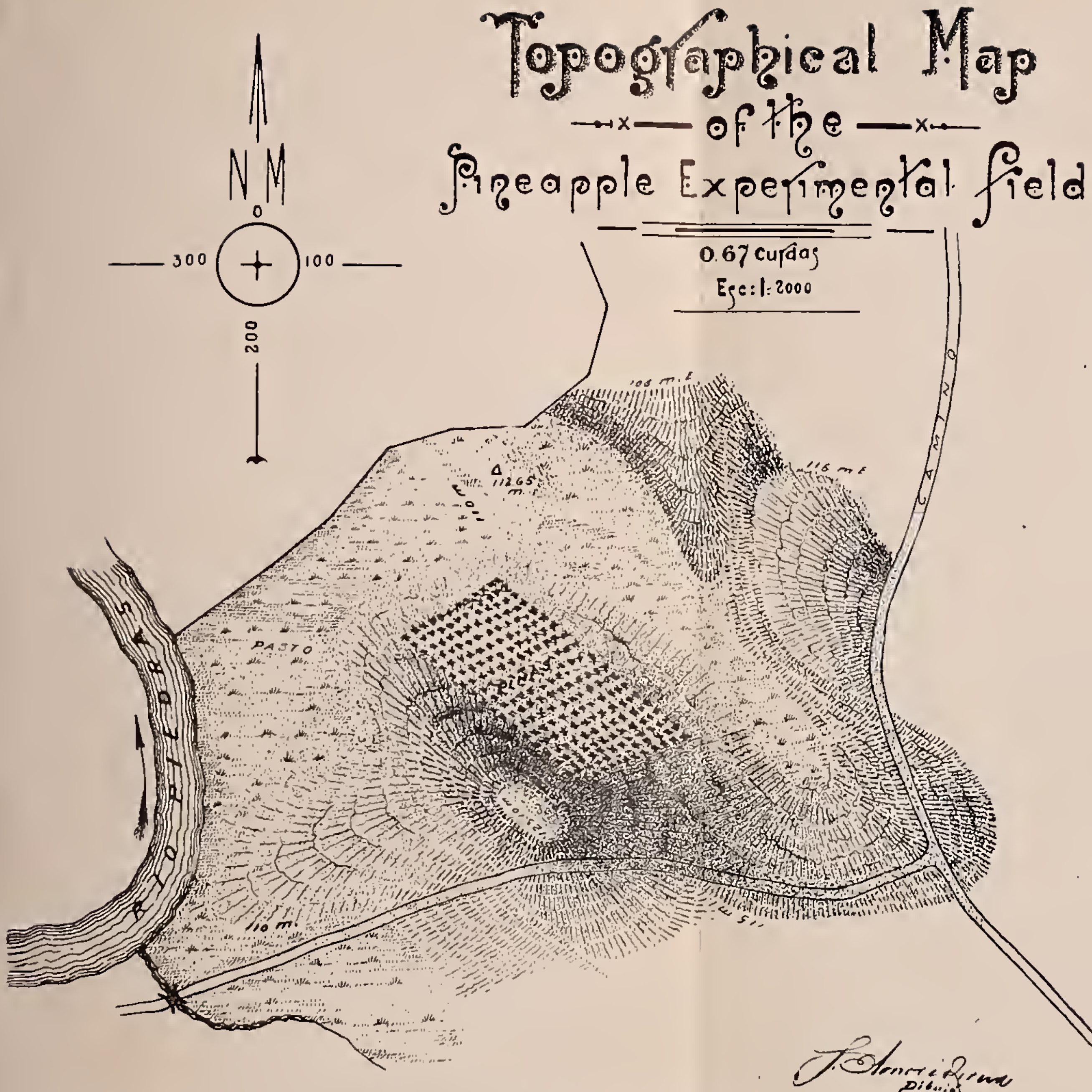

FIG. 1.—A Pineapple Fertilizer Experiment.

PLAN OF EXPERIMENTAL PLOT.

The plan of the experiment is clearly shown in Fig. 2. The field was equally subdivided (see Fig. 2) into (1) an upper lot to be fertilized with a complete fertilizer prepared from dried blood, bone meal and sulphate of potash, and (2) a lower lot to be fertilized with a complete fertilizer prepared from ammonium sulphate, acid phosphate and sulphate of potash. Of the first 36 plots, those which received the same treatment were:

Plots 1, 7, 13, 19, 25, 31—which were not fertilized.

Plots 2, 8, 14, 20, 26, 32—which received a full dose of each ingredient.

Plots 3, 9, 15, 21, 27, 33—whose dose of potash was reduced by two thirds, as compared with Plots 2, etc.

Plots 4, 10, 16, 22, 28, 34—which were not fertilized.

Plots 5, 11, 17, 23, 29, 35—Whose dose of phosphate acid was reduced by two thirds, as compared with Plot 2, etc.

Plots 6, 12, 18, 24, 30, 36—whose dose of ammonium was reduced by two thirds, as compared with Plots 2, etc.

ADDITIONAL PLOTS 37–41.

The phosphoric acid used in all the plots planned heretofore was to be derived from acid phosphate. It must have seemed desirable to try the effect of the same application of phosphoric acid derived from double super-phosphate. The latter would not carry any calcium sulphate along with it, as in the case of the acid phosphate. Accordingly, the field was further planned to include another plot, plot No. 39, identical with Nos. 2, 8, 14, 20, 26 and 32, except for the use of double super-phosphate instead of acid phosphate. Plot 39 duplicated 2, 8, 14, 20, 26 and 32 except that in the lower half dried blood was used instead of ammonium sulphate. The plan of the upper half of plots 2, 8, 14, 20, 26 and 31 was again repeated in an additional plot, plot 40. The latter differed from them, however, in that it was made 120 feet long, so that it occupied the upper as well as the lower portion of the field. The principal function of this plot 40 was a comparison of the relative efficiency of applying the fertilizer directly to the soil or in the axils of the leaves. It would also act as a check on the application of organic nitrogen and phosphorous on the upper portion of the slope by having an identical plot extending also into the lower slope. Finally the broader check plot was provided in plot No. 41.[1]

[1] NOTE.—Although plot 41 is supposed to be a check plot, a note has been found in the records of the Division of Agronomy to the effect that the plot had been fertilized with dried blood.

	LOWER PLOT—INORGANIC NITROGEN AND PHOSPHORUS 60 ft. 120 plats.			UPPER PLOTS—ORGANIC NITROGEN AND PHOSPHORUS 60 ft. 120 plants.	
1	UNFERTILIZED			UNFERTILIZED	
2	36¾ lbs...........	12 lbs. Ammonium sulphate 18¾ lbs. Acid sulphate 6 lbs. Potassium sulphate	(Full dose)	47.9 lbs..............................	13.9 lbs. Dried blood 28.05 lbs. Bone meal 6 lbs. Potassium sulphate
3	32 lbs...........	12 lbs. Ammonium sulphate 18¾ lbs. Acid phosphate 2 lbs. Potassium sulphate	(⅔ less K_2O)	43.9 lbs	13.9 lbs. Dried blood 28.05 lbs Bone meal 2.00 lbs. Potassium sulphate
4	UNFERTILIZED			UNFERTILIZED	
5	24¼ lbs...........	12 lbs. Ammonium sulphate 6¼ lbs. Acid phosphate 6 lbs. Potassium sulphate	(⅔ less P_2O_5)	29¼ lbs...........	13.9 lbs. Dried blood 9.35 lbs. Bone meal 6 lbs. Potassium sulphate
6	28¾ lbs...........	4 lbs. Ammonium sulphate 18¾ lbs. Acid phosphate 6 lbs. Potassium phosphate	(⅔ less N)	38.6 lbs..............................	4.64 lbs. Dried blood 28.05 lbs. Bone meal 6 lbs. Potassium sulphate
(These first 6 plots were repeated 5 additional times so that there resulted 36 plots, every consecutive 6 plots of which were treated identically with the first 6 shown in this plant.)					
37	UNFERTILIZED			UNFERTILIZED	
38	25½ lbs...........	12 lbs. Ammonium sulphate 7½ lbs. Double superphosphate 6 lbs. Potassium sulphate	(Full dose)	27.4 lbs..............................	13.9 lbs. Dried blood 7½ lbs. Double superphosphate 6 lbs. Potassium sulphate
39	38.6 lbs...........	13.9 lbs. Dried blood 18¾ lbs. Acid phosphate 6 lbs. Potassium sulphate	(Full dose)	49.9 lbs..............................	13.9 lbs. Dried blood 28.05 lbs. Bone meal 6 lbs. Potassium sulphate
40	47.9 lbs...........	13.9 lbs. Dried blood 28.05 lbs. bone meal 6 lbs. Potassium sulphate	(Full dose)	47.9 lbs..............................	13.9 lbs. Dried blood 28.05 lbs. Bone meal 6 lbs. Potassium sulphate
41	UNFERTILIZED			UNFERTILIZED	
	60 feet			60 feet	

FIG. 2.—Plan of the Experimental Plots.

PLANTING.

The slips were set in the field in 1917, in two-row beds, 5 feet apart. The plants were set 1 foot apart in the rows. Each plot contained 240 plants in two rows of 120 plants each. This allowed 60 plants to the row for the upper half of the plot and 60 for the lower half.

APPLICATION OF FERTILIZER.

Application of fertilizers were made June 8, 1917; September 1, 1917; and January 22–24, 1918. In the case of plot 40, the fertilizer was applied to the soil in the lower half, and in the axils of the leaves in the upper half.

EFFECT OF TREATMENT.

Notes taken by Mr. H. B. Cowgill, April 3, 1918, show that on this date—

''Chemical Plots No. 2 and its duplicates, having received a full dose of fertilizer, appear, in general, better than the rest.

''Chemical Plots No. 5 and its duplicates, having received two-thirds less phosphoric acid, appear almost as good as Plots No. 2 and duplicates.

''Chemical Plots No. 3, having received two-thirds less potash, appears third best.

''Chemical Plots No. 6 and duplicates, having received two-thirds less nitrogan, appear fourth best. They are poor, but are better than the unfertilized Plots Nos. 1 and 4.

''There appears to have been, at this stage of development, no uniform difference between the plots in the mineral fertilizer series and the corresponding plots in the organic fertilizer series.

''Nos. 38 and 39, in the lower series, appeared about equal.

''No. 39, upper series, appears to be the best of all.

''No. 40, upper and lower series, poor and both about the same.''

THE HARVEST.

The picking and grading of pineapples extended from June 19 to October 8. A good number of pineapples were produced after October 8. These have not been included in this report. The number of fruits harvested per plot and their individual sizes will be found in the adjoining tables.

Pineapple Fertilizer Experiment.

TABLE I.

	Lower Series		*Upper Series*	
Plots	Average size of fruits	Total number fruits harvested	Average size of fruits	Total number fruits harvested
1	40.85	20	43.02	47
2	32.19	51	32.73	57
3	33.66	54	35.48	58
4	38.07	52	37.75	82
5	32.22	45	29.66	53
6	34.37	37	37.31	58
7	42.48	39	38.89	58
8	33.55	59	34.87	64
9	28.82	48	34.94	76
10	44 21	46	37.85	71
11	31.52	75	31.70	81
12	30.74	57	36.16	71
13	45.05	53	40 42	56
14	30.15	78	42.10	56
15	31.52	55	35.66	84
16	36.30	60	47.29	51
17	36.32	74	39.52	75
18	34.22	54	38.46	56
19	39.94	38	41.80	31
20	33.05	61	40.40	60
21	35.85	40	39.29	51
22	42.85	14	41.18	37
23	30.36	51	32.45	54
24	38.19	21	37.53	47
25	44.40	10	27.02	29
26	31.57	40	36.00	72
27	32.57	28	38 82	34
28	47.40	10	43.20	10
29	30.87	55	33.60	50
30	39.37	16	39 20	15
31	44.50	12	44.30	13
32	46.12	38	37.93	29
33	37.44	34	38.59	21
34	45.47	19	43.38	13
35	34.00	49	35 45	44
36	39.39	33	40.71	14
37	46.68	23	42.00	14
38	33.82	69	31.78	37
39	29 39	49	36.80	45
40	37.30	46	37.50	16
41	46.21	37	46.04	46

In order to bring out more comprehensively the effect of each treatment, the following Table II has been prepared by condensing the data given in Table I:

FIG. 3.—A Pineapple Fertilizer Experiment.

Pineapple Fertilizer Experiment.

TABLE II.

UPPER SERIES.

Plots	Treatment	Total No. of fruits harvested	Average No. of fruits harvested	Average size of fruits
(1) 1, 7, 13, 19, 25, 31	Not fertilized	234	39.0	39.24
(2) 2, 8, 14, 20, 26, 32	Full dose	338	56.3	37.33
(3) 3, 9, 15, 21, 27, 33	⅔ less P_2O_5	324	54.0	37.13
(4) 4, 10, 16, 22, 28, 34	Not fertilized	264	44.0	41.77
(5) 5, 11, 17, 23, 29, 35	⅔ less P_2O_5	357	59.5	33.73
(6) 6, 12, 18, 24, 30, 36	⅔ less N	261	43.5	38.22
(Organic) Series average		296.33	49.38	37.9

LOWER SERIES.

Plots	Treatment	Total No. of fruits harvested	Average No. of fruits harvested	Average size of fruits
(1) 1, 7, 13, 19, 25, 31	Not fertilized	172	28.6	42.87
(2) 2, 8, 14, 20, 26, 32	Full dose	325	54.5	34.43
(3) 3, 9, 15, 21, 27, 33	⅔ less K_2O	259	43.16	33.31
(4) 4, 10, 16, 22, 28, 34	Not fertilized	201	33.5	42.38
(5) 5, 11, 17, 23, 29, 35	⅔ less P_2O_5	349	58.16	32.54
(6) 6, 12, 18, 24, 30, 36	⅔ less N	218	36.33	36.04
(Inorganic) Series average		254.33	42.37	36.9

The results obtained would seem to show that nitrogen is the element which most influences production; then, potash. The larger applications of acid phosphate may be interpreted as having been prejudicial. The data are brought together below:

NITROGEN.

	Total No. of fruits (Average)	Average size (No. fruits per box)
Upper series		
Full dose of N	338	37.33
⅔ less of N	261	38.22
Difference	77	—0.89
Lower Series		
Full dose of N	327	34.43
⅔ less of N	218	36.04
Difference	109	—1.61

POTASH.

	Total No. of fruits (Average)	Average size (No. fruits per box)
Upper series		
Full dose of K_2O	338	37.33
⅔ less of K_2O	324	37.13
Difference	14	+0.20
Lower series		
Full dose of K_2O	327	34.43
⅔ less of K_2O	259	33.31
Difference	32	+1.12

PHOSPHORIC ACID.

	Total No. of fruits (Average)	Average size (No. fruits per box)
Upper series		
Full dose of P_2O_5	338	37.33
⅔ less of P_2O_5	357	33.73
Difference	—19	+3.60
Lower series		
Full dose of P_2O_5	327	34.43
⅔ less of P_2O_5	349	32.54
Difference	—22	+1.89

CONCLUSIONS.

It would be premature to draw general conclusions based on the results obtained with one crop. However, the benefit derived from the application of fertilizers is illustrated strikingly by the appearance of the unfertilized plots in the field as compared with the fertilized ones as well as by the number and size of the fruits harvested. (See Fig. 3.) The average total number of fruits produced by the upper plots which received fertilizer in any way was 325 of an average size of 35.37 per box as compared with 249 of an average size of 40.5 per box in the unfertilized ones. The corresponding figures for the lower plots were 288.25 of an average size of 34.13 per box for the fertilized as compared with 186.5 of an average size of 42.63 per box for the unfertilized. In other words, the treatment increased the number of fruits by over 30 per cent and the size of fruits by over 12 per cent for the upper (organic) plots and over 54 per cent and 19 per cent, respectively, for the lower (inorganic) plots.

The results obtained might also indicate that the beneficial effect of the organic fertilizer has been greater than that of the inorganic fertilizer. However, after leaving out the checks, the differences established below do not warrant that conclusion, especially in view of the fact that the difference in number and size of the fruits in the check plots of the upper as compared with the lower suggests a difference in soil conditions.

	Total No. of fruits	
Average of plots fertilized with organic N & P_2O_5	320.	36.60
Average of plots fertilized with inorganic N & P_2O_5	288.75	34.08
Difference	31.75	+2.52

In Table V, given below, the results obtained in plots 39–40 [1] are compared with the average figures from plots 2, 8, 14, 20, 26 and 32 and check plot 37.

[1] Plot 41 is omitted, since, as remarked above, it was fertilized presumably by mistake.